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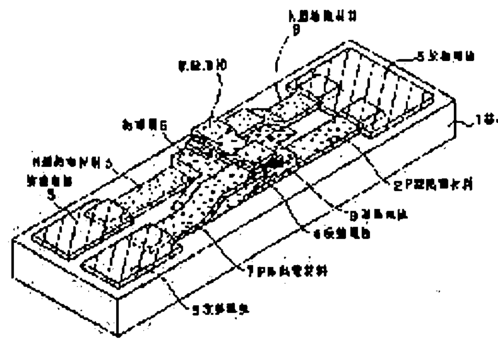
(54) THIN FILM PELTIER THERMOELECTRIC ELEMENT

(57)Abstract:



PURPOSE: To make temperature control possible for a larger amount of heat by a method wherein a thin film Peltier thermoelectric element has at least two or more pieces of the joints between thermoelectric materials, which perform the temperature control, and the joints are laminated.

CONSTITUTION: When a current is made to flow from a part, which is connected to an N-type thermoelectric material 3, of a heat dissipation electrode 5 on the left end of a substrate 1 to the direction of a part, which is connected to a P-type thermoelectric material 7, of a heat dissipation electrode 5 on the same left end by applying a voltage, a cooling is generated in endothermic electrodes 4 and 9 by Peltier effect and heat is generated in the electrodes 5. The areas of the electrodes 5 are formed larger than those of the electrodes 4 and 9 and the electrodes 5 come into contact directly with the atmosphere. Parts, in which the cooling is actually generated, are the joints between a P-type thermoelectric material 2 and the material 7, between the material 3 and an N-type thermoelectric material 8 and between the electrodes 4 and 9 and all the joints are laminated and concentrated on the center of the substrate 1. Accordingly, the cooling ability of the electrodes 4 and 9, that is, a controllable amount of heat can be increased.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention performs generation of heat and endoergic for the thermoelectric material which consists of a thin film according to a Peltier effect, and relates to the thin film Peltier thermoelement which controls the temperature of a temperature control object.
[0002]
[Description of the Prior Art] As a Peltier device which performs temperature control conventionally using the Peltier effect of thermoelectric material, there is a thing of bulk mold structure like Kamimura, Nishida work "thermoelectric semiconductor and its application" Nikkan Kogyo Shimbun, the Showa 63 issue, and a 39-page publication. On the other hand, the thing of thin film mold structure like JP,63-76463,A "a thin film cooling system" is one of things using thin film thermoelectric material.
[0003] The Peltier device of the former bulk mold structure can pass a high current comparatively, and endoergic [in a temperature control joint] and its exoergic effectiveness are also comparatively high. With this structure, in order to fixed-ize temperature as much as possible, generally the cooling fin for heat dissipation and the cooling fan are formed in the joint which does not carry out temperature control.
[0004] The temperature control joint, and ** and the endoergic joint which do not perform temperature control are arranged at substrate top-face inboard, and the Peltier device of the latter thin film mold structure has prepared the fin for heat dissipation by the thin film pattern in the side which approached the joint which does not carry out temperature control of a thermoelectric-material thin film. This structure is setting the minute component and the minute part as the temperature control-ed object comparatively.
[0005] The sectional view of the Peltier device of the conventional thin film mold structure is shown in drawing 9 . the conductor with which an insulating substrate and 36 consist of Cu thin film in 35 -- aluminum 2O3 from which a generation-of-heat side joint and 40 are endoergic side joints as for an electrode, the thermoelectric-material thin film with which 37 consists of a ZnO thin film, and 41, 39 is the cooled device formed on the endoergic side joint, and 38 insulates a cooled device with a Peltier device electrically It is the film. now and a conductor -- if an electrical potential difference is impressed between electrodes 36 and a current is passed, heat will be conveyed to the generation-of-heat side joint 41 from the endoergic side joint 40, the endoergic side joint 40 will be cooled by the Peltier effect of the thermoelectric-material thin film 37, and the cooled object 39 will be cooled.
[0006]
[Problem(s) to be Solved by the Invention] In the above-mentioned conventional example however, with bulk mold structure Semiconductor devices which are functional devices, such as IC (integrated circuit) and LSI (large-scale integrated circuit), When aimed at the temperature control of minute objects, such as the thin film magnetic head and a semi-conductor laser diode, bulk material is used as a thermoelectric material of a Peltier device. Since the cooling fin is still larger, It had the fault that a Peltier device became large too much compared with a temperature control-ed object, and the magnitude of the whole functional device became large too much. Moreover, the above-mentioned functional device consisted of the thin film on a substrate fundamentally, and the process which assembles structurally this thin film functional device and a bulk mold Peltier device to a precision was required for it.
[0007] On the other hand, in a diaphragm structure, since the Peltier device itself is made small with ultra-fine processing technology, such as the FOTORISO etching method, in a thin film and it can form with a thin film on a functional-device substrate, it can use for the temperature control of a very small object functional device, and magnitude of the whole functional device can be made small.
[0008] However, the thermoelectric material which consists of a thin film has the high sheet resistance of the thin film, and several figures also have the small amount of currents which can be measured against bulk. Even

if it passes a high current now, since sheet resistance is high, it will become joule heat loss and efficient temperature control cannot be performed. Therefore, although the traffic of the heat in a Peltier device is greatly influenced by the amount of currents which flows to the thermoelectric material, since it presses down joule heat loss, it can switch on only a small current. Therefore, in the conventional thin film Peltier device, the fault that temperature control of a big heating value could not be carried out had arisen.
[0009] The purpose of this invention is offering the thin film Peltier thermoelement which formed the Peltier device for temperature control with very small structure with the thin film on the same substrate of a functional device, and concentrated power locally, performed temperature control, and made temperature control of a larger heating value more possible than the conventional thin film Peltier device.
[0010]
[Means for Solving the Problem] The thin film Peltier thermoelement of this invention is characterized by having at least two or more thermoelectric-material joints which perform temperature control, and carrying out the laminating of this joint.
[0011] Moreover, in the above-mentioned thin film Peltier thermoelement, it is characterized by for there being few joint laminatings of ** which does not perform temperature control, and the thermoelectric-material joint of a heat sink than the number of joint laminatings of the thermoelectric-material joint which performs temperature control, and the surface area to which this joint touches atmospheric air being large.
[0012] In addition, a thermoelectric material forward in a Seebeck coefficient and a negative thermoelectric material are electrically joined in the shape of a serial to the joint which performs temperature control, and the above-mentioned thin film Peltier thermoelement is characterized by carrying out two or more junction of the joint of the thermoelectric material of a parenthesis.
[0013] With the above-mentioned means, the Peltier device for temperature control is formed with very small structure with a thin film on the same substrate of a functional device, and power is concentrated locally, temperature control is performed, and temperature control of a bigger heating value is made more possible than the conventional thin film Peltier device.
[0014] Below, an embodiment is shown and this invention is explained.
[0015] Drawing 1 , drawing 2 , and drawing 3 show the perspective view of the thin film Peltier device of this invention, a sectional view, and a top view, respectively, 1 is a substrate, the P type thermoelectric material with which 2 and 3 consist of a thin film semiconductor respectively, and N type thermoelectric material, and the endoergic electrode 4 connects in the center of a substrate. 6 is a thin film insulating layer, and the N type thermoelectric material of the same P type thermoelectric material 8 of 7 as 2 and 3 is formed on it, and it is connected by the endoergic electrode 9 in the substrate center section. 10 is an insulating layer and the P type thermoelectric material 2 and the N type thermoelectric material 8 are connected by the heat dissipation electrode 5 at the right end of the illustrated substrate 1. Moreover, the N type thermoelectric material 3 and the P type thermoelectric material 7 are connected to the heat dissipation electrode 5 at the left end of a substrate.
[0016] If a current is now passed by electrical-potential-difference impression in the direction of a part connected to the P type thermoelectric material 7 of the heat dissipation electrode 5 of this left end from the part connected to the N type electrode material 3 of the heat dissipation electrode 5 of the left end in drawing, cooling will arise in the endoergic electrodes 4 and 9 according to a Peltier effect, and generation of heat will arise in the heat dissipation electrode 5. In drawing, area of the heat dissipation electrode 5 is made larger enough than the endoergic electrodes (cooling electrode) 4 and 9, and it is made directly in contact with atmospheric air. Therefore, the heat generated with the heat dissipation electrode 5 radiates heat by the atmospheric free convection, and tends toward atmospheric temperature, i.e., the constant temperature of room temperature extent. On the other hand, since the laminating of the electrode surface product is carried out small, the endoergic electrodes 4 and 9 have the small part which touches atmospheric air directly. Therefore, the degree which absorbs the heat in atmospheric air is small, and the temperature of the endoergic electrode 4 and 9 the very thing falls efficiently.
[0017] The part which cooling actually generates in this thin film Peltier device is a part for the joint of the P type electrode material 2 and 7, the N type electrode material 3 and 8, and the endoergic electrodes 4 and 9. Namely, in this component, this joint carries out at those with four place, and all are carrying out laminating concentration in the center of a substrate. Therefore, an endoergic joint can enlarge the refrigeration capacity of an endoergic electrode, i.e., a controllable heating value, compared with one thin film Peltier device like the conventional example.
[0018] The atmospheric-air touch area of the heat dissipation electrode 5 and the endoergic electrode 9 and an atmospheric natural convection heat transfer serve as an important item in thin film Peltier with it difficult [to carry out forcible heat dissipation only of the heat dissipation electrode with a cooling fan locally]. If the inside of atmospheric air is generally calm now, heat dissipation or the heat flow q which carries out endoergic is

[0019] by the natural convection heat transfer.

[External Character 1]

$q = \bar{h} \cdot \Delta T \cdot l^2$

a formula -- heat sinking plane qH =1.46|deltaT5 l7 |1/4 endoergic side qC =0.73|deltaT5 l7 |1 / 4 -- it has relational expression. (The page 30 of the 5th edition chemical engineering handbook of revision, the Showa 63 Maruzen Co., Ltd. issue for chemical engineering associations)
Here, deltaT is the temperature gradient [K] of atmospheric air, a heat sinking plane, or an endoergic side front face, and l is die length of one side on the front face of a square of a heat sinking plane or an endoergic side [m], and [0020].

[External Character 2]

$\bar{h}$

It is ****** thermal conductance and is [0021].

[Equation 1]

$$\bar{h}_H = 1.46 \mid \Delta T / l \mid ^{1/4} \quad [W/m^2K]$$

$$\bar{h}_C = 0.73 \mid \Delta T / l \mid ^{1/4} \quad [W/m^2K]$$

It is come out and expressed. Therefore, if a heat sinking plane and an endoergic side are these area, a twice as many heat flow as this has the direction of a heat sinking plane, and if die-length [of one side] l of the front face of a heat sinking plane doubles to an endoergic side dimension further and it will increase about 6.7 times and 5 times, an about 33 times as many heat flow as this will arise. Compared with an endoergic electrode, a heat dissipation electrode has more heat flows with atmospheric air, and always tends to approach constant temperature. In contrast, since an endoergic electrode has few heat flows absorbed from atmospheric air, cooling is performed. Thus, it is understood that it is important to enlarge a heat dissipation electrode and heat dissipation joint area, and to make small an endoergic electrode and cooling joint area. Especially in this invention, the laminating of an endoergic electrode and the cooling joint is carried out, the atmospheric-air contact surface is made small, on the other hand, a heat dissipation electrode and a heat dissipation joint are developed in a large area, without carrying out a laminating, and the above is more efficiently attained by enlarging the contact surface with atmospheric air.
[0022] Although the above-mentioned embodiment explained the case where the temperature control-ed section was cooled, when heating the temperature control-ed section conversely, that what is necessary is just to make reverse the direction of a current to pass, a temperature fall and a temperature up are possible and it is understood easily that temperature control of the temperature control-ed section can be performed.
[0023] Although the two-layer laminating of the joint of thermoelectric material and an endoergic electrode is carried out in this embodiment, this invention is not restricted to this, more than a structure top three-layer laminating cannot interfere at all, and it can carry it out.
[0024] There are the following as an ingredient used for the thin film Peltier thermoelement of this invention.
[0025] Namely, as a thermoelectric material, can deposit as a thin film and what has a high performance index as a thermoelectric material is called for. Cu2 O, and NiO and Mn 2O3 A P-type semiconductor metallic oxide, ZnO, MoS and Fe 3O4, FeO, the N-type semiconductor metallic oxide of CuO, There are semi-conductors, such as metallic materials, such as Bi, Co, and Sb, germanium which performed doping of B or P and was used as P type or N type, Si, and Si-germanium, etc.
[0026] Moreover, as electrode material, the object of low resistance with high thermal conductivity is good, and Cu, aluminum, Ag, and Au are mainly used.
[0027] Furthermore, as an insulating material, SiO2, SiN, aluminum 2O3, MgO, etc. are used.
[0028] as a substrate -- what has thermal conductivity small as much as possible -- good -- SiO2 Various glass material and aluminum 2O3 etc. -- it is used. What is necessary is temporarily, just to use these ingredients as an interlayer between a substrate and a thin film Peltier device, when the heat conductivity of substrate material is high.
[0029]
[Example]
Example 1 drawing 4 is the top view of the thin film temperature controller by the thin film Peltier thermoelement which shows the example of this invention, drawing 5 shows the A-A' cross section of drawing 4 in the B-B' cross section of drawing 4 , and drawing 6 shows a temperature control crossed-product layer respectively.
[0030] They are a quartz-glass substrate and mu-c whose 11 is 12 and whose 17 are a semi-conductor in

drawing. Similarly the P type thermoelectric material 13 and 18 which doped B (boron) to Si-germanium (micro crystal silicon germanium) is mu-C. It is the N type thermoelectric material which doped P (Lynn) to Si-germanium. 14 and 19 are the endoergic electrodes which used Cu as the principal member, the endoergic electrode 14 joins the P type thermoelectric material 12 and the N type thermoelectric material 13, the endoergic electrode 19 has joined respectively the P type thermoelectric material 17 and the N type thermoelectric material 18, and it is SiO2. The laminating has been carried out on both sides of the material insulating layer 16. 15 is the heat dissipation electrode which used Cu as the principal member, and has joined respectively independently to the N type thermoelectric material 13 and the P type thermoelectric material 17 in the left-hand side section in drawing 4 . Moreover, in the right-hand side section, the N type thermoelectric material 18 and the P type thermoelectric material 12 are joined with a common heat dissipation electrode, and electrical installation is performed.
[0031] Area on the top view of the heat dissipation electrode 15 is made into 25 times of the endoergic electrodes 14 and 19 by which the laminating was carried out.
[0032] 20 is the insulating layer prepared on the endoergic electrode 19, and is SiO2. It consists of material, and the endoergic electrode 19 reduces direct atmospheric air and the area which touches, and is pressing down the heat flow from atmospheric air small. 21 is a temperature control-ed object and is prepared on the laminating section of the endoergic electrodes 14 and 19.
[0033] When the electrical potential difference was impressed in the P type thermoelectric-material 17 direction from the N type thermoelectric material 13 and the current was now passed with the heat dissipation electrode 15, the current passed the joint of all the thermoelectric material arranged electrically at the serial, an endoergic electrode, and a heat dissipation electrode, cooling arose with the endoergic electrodes 14 and 19, and generation of heat arose it with the heat dissipation electrode 15. By heat dissipation to the atmospheric air in the heat dissipation electrode 15, temperature was able to fall and the endoergic electrodes 14 and 19 were able to reduce the temperature of the temperature control-ed object 21. Moreover, temperature was able to be raised by passing a current to hard flow. Compared with the thin film Peltier device the number of the joints of thermoelectric material and an electrode is [Peltier device] one conventionally, as for the amount of heat of transport of the temperature control-ed object at this time, the twice [about] as many improvement in capacity as this was accepted. Moreover, about -20 degrees C of minimum temperature have improved.
[0034] The manufacture approach of the thin film Peltier thermoelement of this example is shown below.
[0035] It is mu-c on the quartz-glass substrate washed and degreased well first. The thermoelectric material of the P type which consists of Si-germanium material, and N type was deposited by the plasma-CVD method by the thickness of 2 micrometers, and patterning of the thermoelectric material 12 and 13 was carried out by the HOTORISO etching method. The vacuum deposition of the Cu with a thickness of 2 micrometers which has Cr thickness of 100A in under coating and the upper layer was carried out to besides, and patterning of the endoergic electrode 14 and the heat dissipation electrode 15 was carried out by the lift-off method of a photoresist. Furthermore, it is SiO2 with a thickness of 2 micrometers by the plasma-CVD method to up to this. The film was deposited, and patterning was carried out by HOTORISO etching so that the endoergic electrode 14 might be covered in part. The thin film Peltier device section of a lower layer [the process so far] can be formed.
[0036] Next, in order to form the upper thin film Peltier device section, the P type thermoelectric material 17 and the N type thermoelectric material 18 are formed like the above. It connects with the heat dissipation electrode 15 already formed at this time, and a heat dissipation joint is formed. Next, the endoergic electrode 19 and an insulating layer 20 are formed like the above. The thin film Peltier thermoelement to which the laminating of the endoergic electrodes 14 and 19 was carried out here can be formed. Next, if the temperature control-ed object 21 is arranged in the laminating section of the endoergic electrodes 14 and 19, the temperature control of this temperature control-ed object 21 can be carried out. Moreover, when the temperature control-ed object is directly formed on the substrate 11, temperature control becomes possible by surrounding and carrying out patterning of the circumference of a temperature control-ed object with the endoergic electrodes 14 and 19. Moreover, if only this part uses comparatively good aluminum 2O3 (alumina) and the MgO (magnesium oxide) thin film of thermal conductivity as an insulating layer of under coating, temperature control can be carried out still more efficiently.
[0037] With the structure of this example, it is arranged on the endoergic electrode with which the temperature control-ed object was taken out from the laminating joint of thermoelectric material and an endoergic electrode by the longitudinal direction, and temperature control is carried out by high temperature conduction by Cu material of an endoergic electrode. Therefore, it sets to the insulating layer 20 of insulating layers 16 and 20, especially the maximum upper layer, and is SiO2 with small thermal conductivity. Using the film, the heat loss by heat conduction to the vertical direction of a cascade screen is prevented as much as possible, and lateral heat

conduction is raised. With this, objectively, when arranging a temperature control-ed object on the laminating joint of thermoelectric material and an endoergic electrode, heat conduction to the cascade screen vertical direction can also be raised as much as possible by using the comparatively high insulating material of thermal conductivity, such as aluminum 2O3 and MgO, as an insulating layer.

[0038] Moreover, if surface area of the heat dissipation electrode 15 is further enlarged by this example, in order that heat dissipation effectiveness may increase, the temperature control effectiveness in an endoergic electrode can improve further.

[0039] Example 2 drawing 7 and drawing 8 are the flat-surface sectional views which looked at the side-face sectional view and this side-face sectional view of the distilling plant in mind which used the thin film Peltier thermoelement of this invention from the drawing lower part. In this Fig., the Peltier device substrate with which 22 consists of glass material, and 23 are these endoergic electrodes, and the heat dissipation electrode of a thin film Peltier thermoelement and 24 are formed on the Peltier device substrate 22. On explanation, the heat dissipation electrode 23 and the endoergic electrode 24 are connected, and thermoelectric material is created, although omitted on drawing. 25 is radiator covering which consists of aluminum metal material, 26 is heat sink covering which consists of glass material, and it is fixed on the Peltier device substrate and it forms the passage of air. 27 is a fan stationed at the inlet port of this passage, by rotation, was making air flow towards the direction arrow head 28 of airstream, and has discharged air towards the direction arrow head 29 of airstream. 30 is a photovoltaic cell and is being fixed to the Peltier device substrate with 31 contact pins. The current generated by the photovoltaic cell is supplied to a thin film Peltier device and a fan.

[0040] The current now generated when sunlight 32 was irradiated by the front face of a photovoltaic cell 30 flows to a thin film Peltier device, the heat dissipation electrode 23 generates heat, and the endoergic electrode 24 is cooled. The air in atmospheric air is incorporated by the fan 27 here. The heat which consisted of metal material, and was generated with the heat dissipation electrode 23 since thermal conductivity was high conducts the radiator covering 25. When air flows to the crooked passage formed with the radiator covering 25, heat dissipation is performed by the heat dissipation electrode 23 and the radiator covering 25, and air is warmed. Next, the warmed air flows into the passage formed with the heat sink covering 26 with the low heat conductivity which consists of glass material, it collides and the endoergic electrode 24 quenches it. The moisture in this space-time mind ****, and waterdrop 33 occurs on endoergic electrode 24 front face. The generated waterdrop 33 falls and water trapping is carried out to the heat sink covering 26 side.

[0041] Air 1m3 which will be sent by the fan 27 if the temperature of the endoergic electrode 24 is now kept at 5 degrees C when it is the temperature of 30 degrees C of atmospheric-air hollow mind, and 60% of humidity It received and water trapping of about 0.1g water was able to be carried out. Moreover, when the thin film Peltier thermoelement the conventional thermoelectric material and whose junction of an endoergic electrode are one place was used, it carried out that endoergic capacity carried out fresh water generation in mind small in difficulty, and it cut.

[0042]

[Effect of the Invention] A Peltier device can be formed in the same substrate as carrying out the laminating of the thermoelectric-material joint which carries out temperature control in a thin film Peltier thermoelement as explained above, enlarging more area of the joint which does not perform control, arranging two or more joints in the shape of a serial electrically, and the functional device that is a temperature control-ed object as be alike by microstructure, and power is concentrated locally, temperature control is performed, and it is effective in the ability to be able to perform temperature control of a bigger heating value.

[0043] Furthermore, it also has the effectiveness that this Peltier device can be used for the distilling plant in mind.

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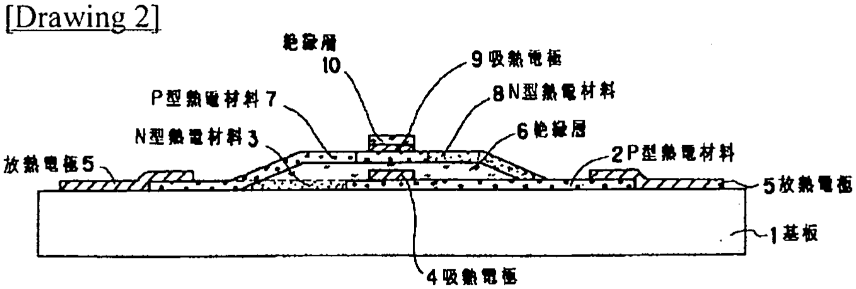
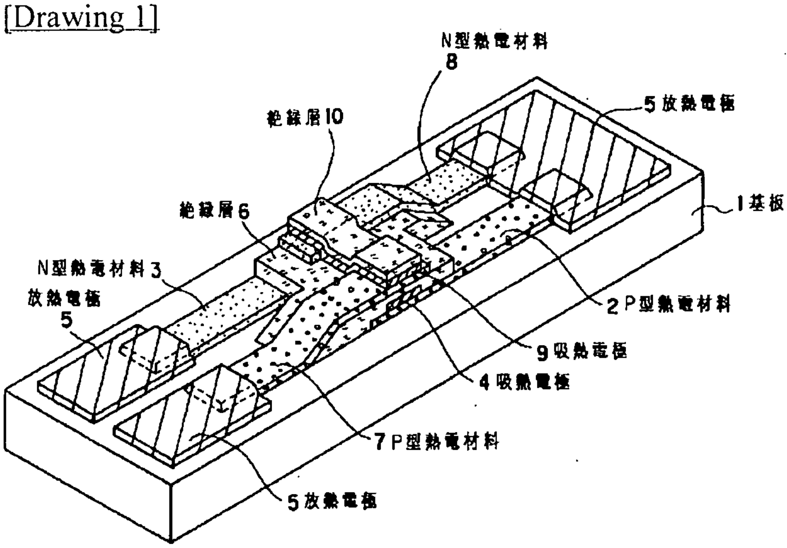
DRAWINGS

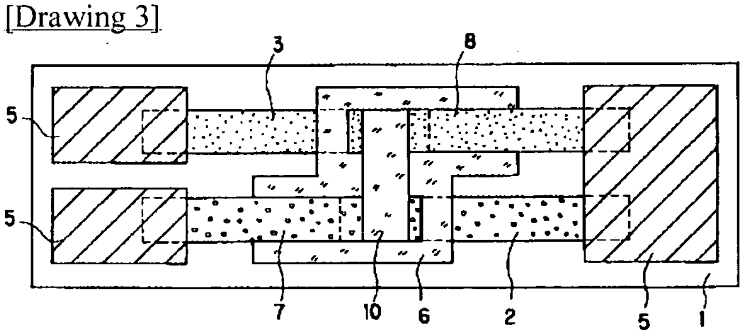
[Drawing 2]



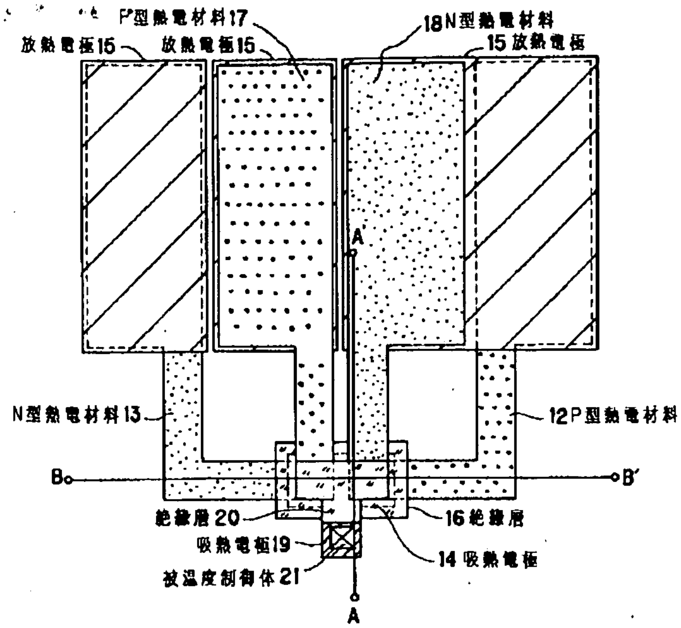
[Drawing 1]



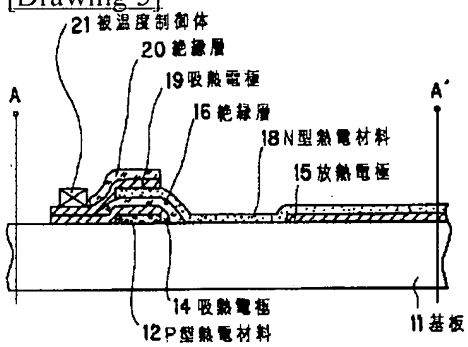
[Drawing 3]



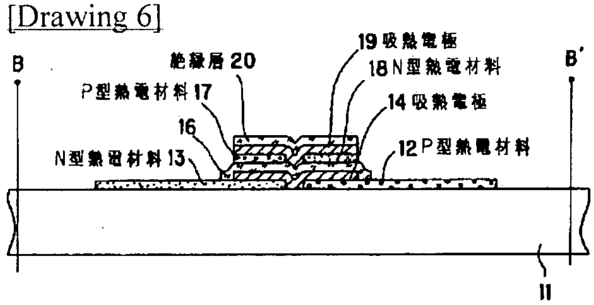
[Drawing 4]



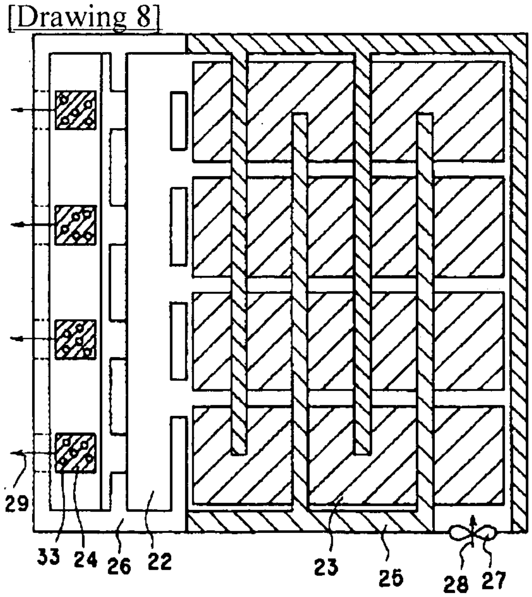
[Drawing 5]



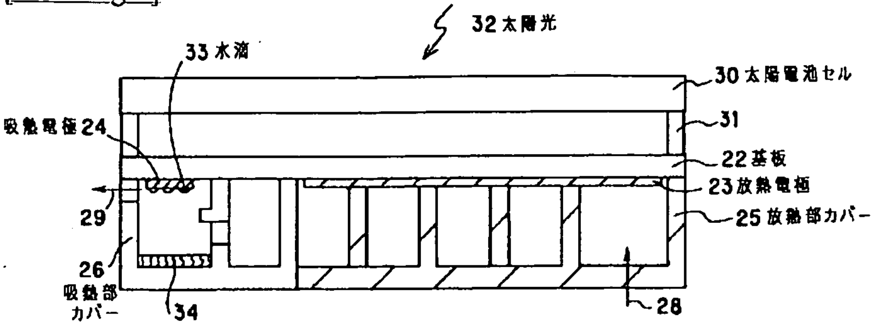
[Drawing 6]



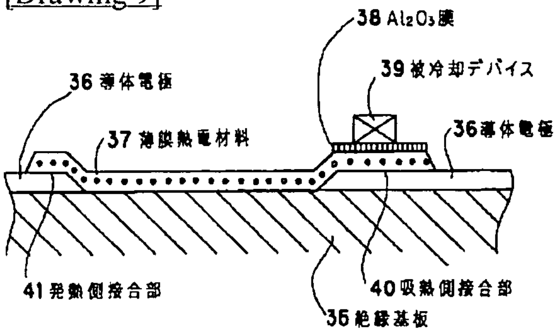
[Drawing 8]



[Drawing 7]



[Drawing 9]



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